ASL U-64-32

FACILITY FORM 602

N65 15185 (ACCESSION NUMBER)

29 (PAGES)

CR 60212 (NASA CR OR TMX OR AD NUMBER)

(THRU)

1 (CODE)

15 (CATEGORY)

VOLUME I
FINAL REPORT

GPO PRICE $ ____

OTS PRICE(S) $ ____

Hard copy (HC) 2.00

Microfiche (MF) .50

Phase I

Contract NAS8-11404

Feasibility Study and Development of a Reliable and Accurate Common Bulkhead Corrective Measurement System

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

Astro-Space Laboratories, Inc.
2104 Memorial Parkway, S.W.
Huntsville, Alabama 35801

ASL U-64-32

VOLUME I
FINAL REPORT

Phase I

Contract NAS8-11404

Feasibility Study and Development
of a Reliable and Accurate Common Bulkhead
Corrective Measurement System

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

Astro-Space Laboratories, Inc.
2104 Memorial Parkway, S.W.
Huntsville, Alabama 35801

VOLUME I
FINAL REPORT

FEASIBILITY STUDY AND DEVELOPMENT OF A COMMON BULKHEAD CORRECTIVE MEASUREMENT SYSTEM

Contract No. NAS8-11404

Prepared by:

R. C. Martin
Chief Engineer

C.E.P. Green
Staff Engineer

Approved by:

Dr. F. K. Mueller
Vice President

TABLE OF CONTENTS

INTRODUCTION

This is the final report of Phase I of the work being performed by Astro-Space Laboratories for the National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Alabama, under Contract No. NAS8-11404. The work constituted a feasibility study for the design and development of a reliable high-precision measurement system for use as corrective measurements in a three-dimensional application. This measurement system study was initiated 26 June 1964, and was primarily concerned with the three-dimensional contour measurements of the forward and aft skins of the Saturn S-II common bulkhead for the purpose of driving a digitally programmed milling-machine to cut accurate double mating curvature surfaces of fiberglass-honeycomb-fill segments within a tolerance range of ±0.005 inches.

For the test purposes of this study NASA delivered to Astro-Space Laboratories, two 105-inch bulkheads. A revision to the contract was necessary to furnish ASL with an electrically driven turntable for mounting and rotating the model bulkheads. This allowed measurement tests to be conducted accurately, with relatively simple test fixtures, and to also simulate the procedure of data acquisition of the much larger bulkhead, needed for the Saturn S-II.

SUMMARY

The plan of study of the measurement problem was, first, to measure the three dimensional contour of the aft bulkhead, then to measure the distance, or space, between the aft and forward bulkheads at a sufficiently large number of known points. These two sets of measurement data could then be converted into an accurate three-dimensional description of the space between the bulkheads, and therefore, of the required honeycomb-fill segments.

This phase of the program, consisting of a study and evaluation of existing measuring devices, was divided into two areas. The first area of study was concentrated upon techniques for measuring the inside distance between the forward and aft bulkheads while they were clamped

together for this purpose. This measurement taken in a sufficiently large number of points would give the required thickness of the honeycomb fiberglass-filler. It was surmised, it was much better to measure a small distance directly than to obtain the distance by subtracting two larger measurements. With this in mind, ASL directed its investigation toward measuring the distance between the two bulkheads directly. The only technique investigated which gave promise of being able to make this direct measurement, within stringent tolerances, was the one using ultrasonic echoes. ASL investigated equipment availability and the present state-of-the-art in this field, together with data taken during laboratory testing.

The second area in this phase of the study was the required measurement of the contour of the forward bulkhead. It was found that this problem could be solved in a fairly straight forward manner by use of a profile tracing device with the required accuracy. However, such a device would be extremely large and of heavy construction to provide measurements to an accuracy approaching 0.001 inch over the distances involved (a 33 foot diameter surface). For this reason, thought was given to a measuring system which would, in effect, measure only a relatively small zone of the bulkhead at one time. This measurement could be made fairly easily to the required accuracy, since it would be over a limited area. The remaining problem was then the specific definition of the measured area to the whole bulkhead. This definition, however, seemed to require a much less accurate measurement, so that a simpler and less expensive measuring device could be used. From various investigations it would seem that the contour measurements could be easily acquired by using one of the many linear encoders now on the market.

Generally, ASL's evaluation of the three-dimensional problem was that the thickness measurement, being a state-of-the-art technique, would be the most difficult to design and develop. With this in mind much of the engineering effort was directed toward accomplishing a system in the ultrasonic field to give an accurate description of the thickness of the honeycomb-filler.

ULTRASONIC ECHO TECHNIQUE

A beginning was made in evaluating the "Ultrasonic Echo Technique" method of pulse counting in the following manner.

A test set as pictured in Figure 1, consisting of an 18-inch square box of 1/4-inch aluminum and containing a movable 10-inch diameter cylinder was fabricated. During the pulse echo tests the inner cylinder was positioned at a known distance from one side of the box by use of gage blocks between the surfaces. The volume between the inner surface of the box and outer surface of cylinder was then filled with water. The ultrasonic transducer was placed against the outer surface of the box and positioned so that the ultrasonic beam would go through the 1/4-inch aluminum wall of the box, traverse the known distance through the water to the outer surface of the cylinder, and be reflected back through the water and box wall to the transducer. Data taken by this method indicated that the ultrasonic measurement of the water filled space between the 1/4-inch thick aluminum box and cylinder was entirely feasible and to an accuracy of far better than the 0.005 inch as required by the NASA contract.

Pulse Display

Figure 2 illustrates the pulse display. The initial pulse on the left-hand side of the pattern represents the burst of ultrasonic energy which is applied to the transducer. The second pulse is the first pulse reflected from the first aluminum-water interface. Subsequent pulses in the first group are caused by multiple reflections within the aluminum wall. The first pulse in the second group of pulses is the first pulse to return through the water from the second water-aluminum interface. Therefore, the time between the groups of pulses is the indication necessary to give the pulse travel-time through the water; specific pulses must be used as measuring points.

From the pulse display (Figure 2) it can be seen that the total travel-time, through the aluminum box wall, through the water and back through the aluminum wall to the transducer can be obtained by using the following formula:

$$T_t = 2\frac{D_1}{V_a} + 2\frac{D_2}{V_w}$$

where:

T_t = Total time between initial pulse and return pulse.
V_a = Velocity of sound in aluminum
V_w = Velocity of sound in water
D_1 = Distance to be measured in aluminum
D_2 = Distance to be measured in water

The total time of travel is made up of two parts; the time required to traverse the aluminum wall two times, $T_a = 2\frac{D_1}{V_a}$ and the time required to traverse the water two times, $T_w = 2\frac{D_2}{V_w}$. Since the time between any two adjacent pulses is $T_a = 2\frac{D_1}{V_a}$ the time between the <u>second</u> pulse of the first group and the <u>first</u> pulse of the second group is directly the time of travel through the water and can be written as $T_w = 2\frac{D_2}{V_w}$ therefore the thickness of the honeycomb-filler can be said to be $D_2 = \frac{T_w V_w}{2}$. For actual time measurement, it is sometimes more desirable to use, not the second, but the third or fourth pulse as the initial pulse. This is permissible since all adjacent pulses are equally spaced in time so that if the n'th pulse is used as the initial pulse in the first group, the time measurement is simply made to the n-1 pulse of the second group.

Acoustic Velocity

It can be readily seen that the determination of distance by the ultrasonic echo method is accomplished by measuring the time required for an ultrasonic pulse to traverse the distance. Therefore this relationship can be expressed as $D = V \cdot t$.

where:

D = The required distance
V = Velocity of sound in material
t = The time taken by the pulse to travel through the material

For most materials, the velocity of sound is temperature-dependent. With the speed of sound in water increasing approximately 0.179 percent; per degree C increase in temperature, this would then place an accuracy limitation upon the distance measurement, dependent upon the accuracy with which the temperature is known. While very accurate temperature measurements can be made, for ASL's application a more attractive solution would be to use a liquid which had a lower, or zero, change in sound velocity with temperature. After several experiments such a liquid was determined to be a mixture of alcohol and water. Preliminary calculations indicated that a mixture of approximately 20% alcohol and 80% water, would give us little or no change in velocity with temperature. However, tests determined that the proper mixture would, in fact, be 15% alcohol and 85% water.

Ultrasonic Instrument Evaluation

The most commonly used method of time measurement in ultrasonic echo technique is limited in accuracy by the mechanical measurement of the spacing of the pulses displayed on an oscilloscope screen. The accuracy limitations inherent in this method are a lack of linearity in the ultrasonic unit time base. These limitations were overcome by the use of a digital counter and a precision frequency standard to provide an accurate time base. A preliminary survey of the equipment operating to the required accuracy was made, and the equipment was found to be commercially available (see list and specs of equipment in Appendix A). An example can be given in the Hewlett-Packard Company 5275A Time Interval Counter which has a resolution of 0.01 microsecond. This precision sets an accuracy limit on an ultrasonic measurement through water of approximately 0.0003 inch. Since the speed of sound in aluminum is approximately four times that in water, the accuracy limit on measurements made in aluminum will be approximately 0.0012 inch. This is well within the required tolerance.

Ultrasonic Measuring System

The mode of operation of the ultrasonic measuring technique incorporates commercially available equipment and Astro-Space Lab designed control circuits.

The control circuits were specifically developed for the purpose of precise selection of the correct start and stop pulses to trigger a time interval counter on and off.

Operation of Ultrasonic System (General)

A burst of (10 MC) pulses is produced by shocking the crystal in the transducer into oscillation with a single high voltage pulse from a pulse generator. The pulsed crystal provides an initial burst of pulses which traverses the aluminum wall of the immediate bulkhead and the liquid distance to the outer surface of the other bulkhead and is then reflected back on approximately the same path to the transducer. By using the control circuits which have time constants designed into them, it is then possible to select a start pulse from the initial burst to trigger the time interval counter "ON" and from the ultrasonic echo select a stop pulse for triggering the counter "OFF". The 10 megacycle frequency signal produced and received by the transducer is fed to a cathode follower circuit whose prime purpose is to match the impedance of the high frequency signal from the transducer to the input of the cascaded amplifiers (See Figure 3). The cathode follower also serves to limit the output level of the signal to prevent damage to the amplifiers. The signal being amplified is then fed to one of the two inputs to the NAND gates, which are designed for gating the desired portion of the signal which is necessary to start or stop the counter. The gates will only produce an output to the counter (which is a negative going pulse) when two positive signals are applied simultaneously to the two inputs, therefore it is necessary to have a second input. This is provided by a monostable multivibrator which has a controlled time constant, whereby, by selecting the properly timed multivibrator signal, the desired portion of the signal may gate the time interval counter on or off. The time interval counter uses a 1 MC oscillator, which is multiplied to 100 MC, as its time base to count the time in hundredths of microseconds that it takes, for the sound waves to travel the distance through the liquid and back (See Figure 4). The counter also indicates this time by a seven-column neon readout with a decimal point. From the counter the time data will then be recorded on a digital readout printer.

CONCLUSION

The results of data acquired from the ultrasonic measuring technique were extremely successful. The simulated bulkhead test setup and the information obtained from it proved that measurements necessary to drive digitally programmed milling-machines to cut accurately double-mating curvature surfaces on fiberglass-honeycomb fill-segments was entirely feasible and well within the required tolerances.

Phase I of the study program has not only proven the feasibility of the ultrasonic echo measuring technique, but has also produced a working device for accurately measuring the forward bulkhead wall thickness and the distance between the forward and aft bulkheads on a single point basis. The ultrasonic measurement system has been built, for the most part, of commerical equipment of proven accuracy and reliability. The next step in the development of the bulkhead measuring system should be the design and construction of an automated measuring head which would allow the gathering of data on the 105-inch bulkhead. These measurements would in turn be used to compute and punch a machine control tape for automatically milling honeycomb fill sections. These sections would then be used to prove the system concept by being assembled into a complete bulkhead.

The system concept is based upon a completely flexible measuring panel in that the panel, once constructed, will not be limited to any one size of bulkhead. It is this versatility which gives the system its appeal over systems which require "hard-tooling" measuring devices, and which are limited in their application to one specific structure.

APPENDIX A

EQUIPMENT APPLICATION

The "Ultrasonic Measuring System" consists of equipment which is commercially available and, "Control Circuits", especially designed by ASL for the selection of the correct pulses. The commercial equipments application to the system is as follows.

Pulse Generator

Considered the heart of the system, primarily because it is from this unit that the pulses which start the mode of operation originate. These pulses are termed "Initial" and "Trigger", and later, when describing the system as a whole, these designations will be used frequently.

Transducer

Uses a crystal of 10 megacycle range and is of the transmit and receive type.

Power Supply

Used precisely for what the name implies. For our purpose we use three of these units at present, but later it may be possible to mount a single unit within the console.

Amplifiers

These are used for the amplification of the signal as shown in the Block diagram. (Figure 5.) Again we use three of these units but later it may be possible to use two.

1 MC Oscillator

This is used as a time base by another piece of equipment called the "Time Interval Counter".

Time Interval Counter

Converts the 1 MC standard frequency to 100 MC, and counts units of time of the one hundred megacycle (100 MC) signal in microseconds and presents to the recorder a four-line binary-coded decimal output, in which the least significant digit corresponds to 0.01 microsecond. This least significant digit represents an acoustic velocity through water of 0.0003" and through aluminum of 0.00125 inches (Figure 6).

Digital Recorder

Accepts the readout from the counter and records it through its digital mechanism on paper in a number of columns.

CONTROL CIRCUITS

Switching Mode Design

Pulse selection to the Hewlett Packard 5275A Time Interval Counter is done by a number of networks consisting of monostable or one-shot multivibrators and "NAND" gates as shown in Figure 4. The basic operation of these circuits is as follows: the multivibrator is triggered by a positive external signal source, in this case a pulse generator producing an output signal of calculated amplitude and duration to the base of T5 in the "NAND" gate circuit. When a positive signal occurs at the base of T6 in the "NAND" gate while being held positive by the multivibrator, T5 and T6 will then conduct producing a negative output, allowing the selected pulse from the ultrasonic transducer to pass on to the Time Interval Counter. At present, the pulse selection circuitry calls for three (3) multivibrators and four (4) "NAND" gates. These will be distributed in various positions throughout the "Ultrasonic Distance Measuring System".

Figure 3 shows the "Cathode Follower and Voltage Limiter Circuit". This has two objectives as follows:

1. Limit the initial pulse to some voltage below 5 volts to prevent overloading the amplifiers.

2. To match impedances from transducers (high at 2000 ohms) to amplifiers (low at 50 ohms). Basically, R1 and diodes CR1 and CR2 make up the voltage limiting circuit. The "Nuvistor Tube 7586" is the Cathode Follower and with the surrounding circuitry matches the high input impedance to a low output impedance. Selection of the "Nuvistor Tube" was made because of its low noise characteristics and low operating voltage at the plate.

The above paragraphs describe very briefly the inter-circuitry being designed at ASL. Perhaps there will be changes made when the overall measuring system is assembled. Later, when the system is proven, it will be possible to give a detailed description of all the circuitry.

OPERATION OF ULTRASONIC SYSTEM

Enclosed with this report is a Schematic (Figure 7) showing the designed Pulse Selection circuitry and the commercial equipment as a fully operational measuring system.

The mode of operation for the correct selection of desired pulses begins with the "Initial Pulse" from the pulse generator which is variable in amplitude, duration and repetition rate. The "Initial Pulse" is used to shock the crystal, located on the transducer head, into high frequency oscillation. This is fed to the Nuvistor cathode follower which matches impedance and also limits the output to a low voltage signal to prevent damage to the amplifiers. The high-frequency signal is then passed on to the amplifiers for amplification and coupled to one of the inputs to the "NAND" gates. These gates will only conduct when two inputs of positive polarity are applied simultaneously so the input from a flip-flop network, which is variable in time and duration, effectively controls the operation of these "NAND" gates.

The "Trigger" pulse from the pulse generator, which is of a fixed value but may be advanced or delayed as necessary with respect to the "initial" pulse, turns the flip-flop networks to the "On" position. For this system the trigger is delayed 2 μ/sec to eliminate the initial pulse from the control circuits.

The "Start" pulse is the output of a specific "NAND" gate which, when coupled to the counter, turns it on. This pulse is produced in the following manner; a flip-flop is turned on and produces a positive square wave of 2 μ sec duration. This signal is coupled to the input of a "NAND" gate so that when the high frequency signal from the cathode follower is fed to the other input of the gate, both inputs being positive, they will then produce an output pulse to the counter. To define the "Start" pulse it can be said to be, "the very first pulse occurring after the delay of the 2 μ/sec of the high-frequency signal".

The "Stop" pulse is also the output of a specific "NAND" gate but we have two situations whereby we want to measure thickness of aluminum as well as distance between bulkheads. This means extra flip-flops and gates of varying time constants. The operation of the stop pulse is much the same as the start pulse. The difference being the use of a 250 μ sec flip-flop. Any positive signal occurring at the adjacent input of the "NAND" gate during the 250 μ sec will produce a negative signal output; this output is then coupled to a phase inverter to produce a positive going signal which is then fed to one of the two inputs of the final "NAND" gate. The other input to the gate is produced in a square wave form, from either the 2 μ sec or the 14 μ sec network, depending on the position of the selector switch. This signal is then coupled to the input of a buffer amplifier which inverts the signal to a negative value feeding it to the second input of the final "NAND" gate. The "Stop" pulse "NAND" gate will be cut off only when either flip-flop is triggered "On" for the required time duration. The "Stop" pulse is produced when the flip-flop signal elapses, provided the high-frequency signal pulses are present at the adjacent input of the gate. This pulse stops the counter and the time is recorded on the printer of the digital recorder.

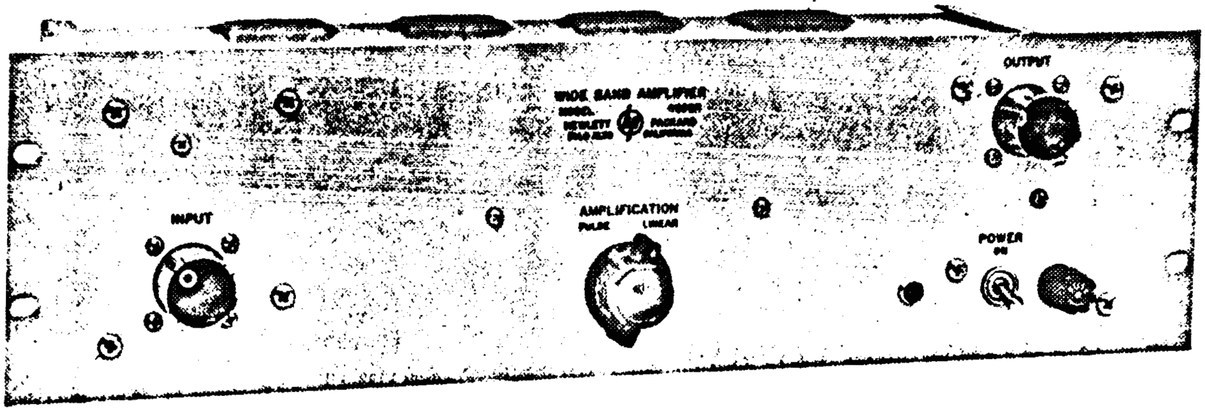


Figure 1-1. Model 460BR Wide Band Amplifier

Table 1-1. Specifications

Model 460BR Wide Band Amplifier

Frequency Response:

High Frequency - closely matches Gaussian curve when operating into a 200-ohm resistive load. 3 db point is 120 mc.

Low Frequency - off approx. 3 db at 20 kc when operating into a matched load. Off approx. 3 db at 3 kc when operating into an open circuit (i. e., CRT plates).

Gain: Nominally 15 db into 200-ohm load

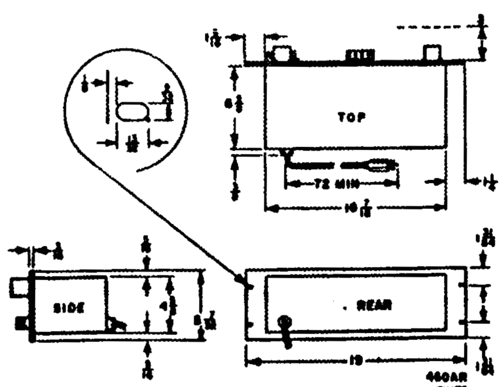
Sinusoidal Output: 8 volts peak into a 200-ohm load or 16 volts peak into an open circuit

Pulse Output

Input Pulse	Maximum Output Voltage			
	Pulse		Linear	
	Unloaded	Loaded	Unloaded	Loaded
-	+16v	+8v	+16v	+8v
+	-125v	-60v	-16v	-8v

Note: +8v input required for -125v output

Dimensions:



Input Impedance: 200 ohms

Output Impedance: 200 ohms

Noise Figure: Less than 6 db

Delay Characteristics: Approximately .016 μsec

Rise Time: Nominally 0.003 μsec. No appreciable overshoot

Power Supply: 115/230 volts ±10%, 50/1000 cps, 50 watts

Accessories Available:

- 11006A Patch Cord: 200 ohms, 2 ft long
- 11007A Patch Cord: 200 ohms, 6 ft long
- 11008A Panel Jack: for 200-ohm cables, low capacitance
- 11009A Cable Plug: for 200-ohm systems
- 812-52 Cable: 200 ohms cable in length to specification
- 11010A 50-ohm Adapter: Type N to 460, 50-ohm termination
- 11011A Adapter 410B VTVM to 460, 300-ohm termination
- 11012A Connector Sleeve: joins two 11009A Cable Plugs
- 11013A Adapter: for connecting to 5XP CRT
- 11015A Adapter: Type N to 460, 200-ohm termination
- 11016A Adapter: Type N to 460, no termination
- 11017A Adapter: 410 VTVM to 460, 200-ohm termination
- 11019A Adapter: for connecting to 150A Oscilloscope plates

SECTION I
GENERAL INFORMATION

1-1. GENERAL INFORMATION.

1-2. The Hewlett-Packard Models 461A and 462A Wide Band Amplifiers are unilateral devices that can faithfully amplify sinusoidal and complex signals having spectral energies in the 1 kc to 150 mc range. The Model 461A is designed for amplification of sinusoidal signals; the Model 462A is best suited for amplification of complex and pulse waveforms. The Model 461A will amplify signals with less than ±1 db variation across the 1 kc to 150 mc range;(the Model 462A provides a pulse response that has a rise and fall time of less than 4 nanoseconds.) Input impedance is 50 ohms and output impedance is designed to work into a 50-ohm load. With the gain setting at 20 and 40 db, input voltages of 50 mv and 5 mv can be applied, producing a maximum of 0.5 volts rms at the output (1 Volt P-P Model 462A). The Models 461A and 462A are shown in Figure 1-1. Specifications are given in Table 1-1.

1-3. Since the Models 461A and 462A are nearly identical, this manual will discuss the instruments in terms of the Model 461A. The Model 462A will be mentioned only when its operation differs from that of the Model 461A.

1-4. ACCESSORIES AVAILABLE.

1-5. The ℗ 11048A 50-ohm feedthrough termination is an available accessory that is connected at the output of the Model 461A. The feedthrough termination should be used to insure that the Model 461A is operating into its rated impedance in the event the instrument is connected to a device with an impedance greater than 50 ohms.

Table 1-1. Specifications

MODEL 461A / MODEL 462A	GENERAL
MODEL 461A	Pulse Overlaod Recovery: Less than 1 μsec for 10 times overload.
Frequency Range: 1 kc to 150 mc	Equivalent Input Noise Level: Less than 40 microvolts.
Frequency Response: ±1 db when operating into a 50-ohm resistive load (500 kc reference).	Input Impedance: 50 ohms, nominal.
Output: 0.5 volts RMS into 50-ohm-resistive load.	Gain at 500 kc: 20 or 40 db ±0.5 db selected by front panel switch.
Distortion: Less than 5% at rated output.	Power Supply: 115 or 230 v ±10%, 50 to 1000 cycles, 5 watts
MODEL 462A	Dimensions: 3-14/32" (8.7 cm) wide x 11" (27.9 cm) long.
Pulse Response: Rise and Fall Time: Less than 4 nanoseconds Over and Undershoot: Less than 5%.	Weight: Net: 4 lbs (1.8 Kg). Shipping: 6 lbs (2.7 Kg).
Pulse Duration for 10% Droop: 30 μsec.	Accessory Furnished: Detachable Power Cord
Output: 1 volt peak-to-peak into 50-ohm load.	Accessory Available: ℗ 11048A 50-ohm feedthrough termination.

Table 1-1. Specifications

OUTPUT PULSE

Source Impedance: 50 ohms on the 50-volt and lower ranges; approximately 1500 ohms on the 100-volt range.

Pulse Shape

Rise and Fall Time: <13 nsec on 50-volt and lower ranges, except on positive 50 volt pulse <15 nsec; typically <10 nsec with vernier set for maximum attenuation. 100V range typically 15 nsec.

Pulse Amplitude: 100 volts into 50 ohms. An attenuator provides 0.2 to 100 volts in a 1, 2, 5, 10 sequence (9 ranges). Vernier reduces output of 0.2 v setting to ≈ 80 mv and provides continuous adjustment between ranges.

Polarity: Positive or negative.
Overshoot: < 5%, both leading and trailing edges.
Pulse Top Variations: <4%.
Droop: < 6%.
Preshoot: <2%.
Pulse Width: 50 nsec to 10 ms in 5 decade ranges. Continuously adjustable vernier.
Width Jitter: <.05% of pulse width + 1 nsec.
Pulse Position: 0 to 10 ms advance or delay, with respect to trigger output (5 decade ranges). Continuously adjustable vernier.

REPETITION RATE, TRIGGER AND TIMING.

Internal

Repetition Rate: 10 cps to 1 mc (5 ranges), continuously adjustable vernier.

Rate Jitter: < 0.5% of the period.

Manual: Push button single pulse, 2 cps maximum rate.

External

Repetition Rate: DC to 1 mc
Sensitivity: < 0.5 v pk
Slope: Positive or negative
Level: Adjustable from -40v to +40v

External Gating: +8 volt signal gates pulse generator on. Maximum signal, +40v.

Double Pulse

Minimum Spacing: 1 μsec on the .05 to 1 μsec pulse width range. On all other ranges 25% of upper limit of Width range.

Trigger Output

Amplitude: 10 v into 1000 ohms.
Width: 0.05 μsec, nominal.
Polarity: Positive or negative.
Jitter: < 0.05% of advance or delay setting +1 ns (between trigger pulse and output pulse).

GENERAL

Maximum Duty Cycle: 10% on 100 and 50 volt ranges; 25% on 20 volt range; 50% on 10 volt and lower ranges.

Power: 115 or 230v ±10%, 50 to 60 cps, 325 watts.

Dimensions: 16-3/4 in. wide, 7-1/4 in. high, 18-3/8 in. deep overall; hardware furnished for quick conversion to 7 in. x 19 in. rack mount, 16-3/8 in. deep behind panel.

Weight: Net 35 lbs. Shipping 48 lbs.

PULSE GENERATOR

SECTION I
GENERAL INFORMATION

1-1. GENERAL.

1-2. The Hewlett-Packard Model 101A 1 MC Oscillator (figure 1-1) is a high-stability, crystal-controlled oscillator providing low-distortion 1-mc and 100-kc outputs. Long-term stability of 5 parts in 10^8 per week is attained by careful oscillator design and by housing a high-quality crystal in a constant-temperature oven. A front panel adjustment allows oscillator adjustments of approximately 1 part in 10^6. Internal adjustment allows approximately 6 parts in 10^6 total range.

1-3. USES.

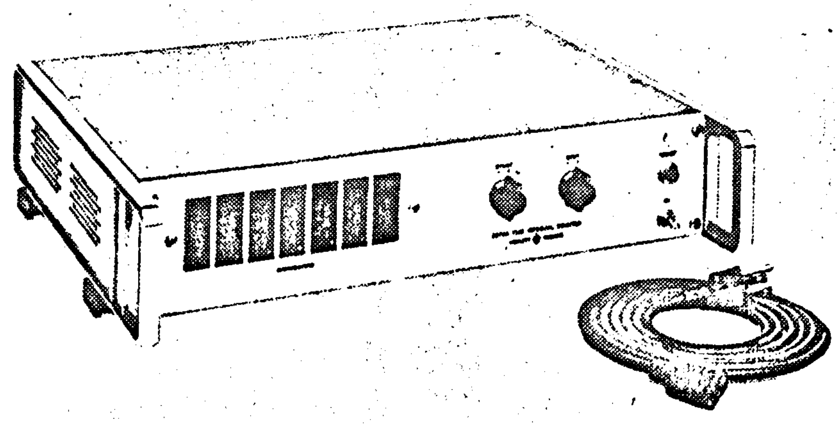
1-4. The Model 101A supplies at least 1 volt rms into a 50-ohm load. As many as 20 Hewlett-Packard Model 5275A Time Interval Counters can be supplied time base signals by the Model 101A(assuming counters are at oscillator location). It can be used as a high-performance secondary frequency standard or as an external time base for many types of electronic counters. The low output impedance of the Model 101A makes it compatible with 50-ohm distribution systems, allowing one precision oscillator to supply signals to several systems. This eliminates errors caused by using timing signals from different oscillators.

1-5. SERIAL PREFIX.

1-6. The Model 101A carries a five-digit serial number with a three-digit prefix (000-00000). If the prefix number on the instrument agrees with the prefix number noted on the title page, this manual applies to that instrument directly. Manual changes may be included with the manual to describe changes which are necessary so that it can be used with instruments having other serial prefixes.

Table 1-1. Specifications

STABILITY: Short term, 3 parts in 10^8 Long term, 5 parts in 10^8 per week	POWER: 115 or 230 volts ±10%, 50 to 1000 cps, 2 to 15 watts depending on oven cycle
OUTPUT FREQUENCY: 1 mc, 100 kc (sinusoidal), rear BNC connectors	ACCESSORIES FURNISHED: Power cable, 7-1/2 feet long: three-conductor cable equipped with molded NEMA grounding-type plug and three-pin polarized connector
OUTPUT VOLTAGES: 1-volt rms minimum into 50-ohm load	Signal cable, RG-58C/U, 51-1/2 inches long overall; each end equipped with UG-88/U connectors
SOURCE IMPEDANCE: Approximately 21 ohms; value depends on load; shunt capacity of 3000 pf will not appreciably load output	Plug-in etched board extender, type M65A (for easy maintenance)
DISTORTION: Less than 4% into rated load	Set of rack-mounting hardware
OVEN TEMPERATURE INDICATOR: Front panel dial thermometer	Operating and Service Manual
FREQUENCY ADJUSTMENT: Front panel: screwdriver adjustment with range of approximately 1 part in 10^6 for calibration from primary standard	DIMENSIONS: 3-15/32 in. (8.81 cm) high, 16-3/4 in. (42.55 cm) wide, 11-1/2 in. (29.24 cm) deep behind panel
INTERNAL: Coarse adjustment inside oven sets range of front panel adjustment; total range approximately 6 parts in 10^6	WEIGHT: Net 12.5 lb (5.675 kg) Shipping 19 lb (8.64 kg)



SPECIFICATIONS

Range: 10 nanoseconds to 0.1 second

Resolution: 10 nanoseconds

Accuracy: ±10 nanoseconds ±time base accuracy

Time Base Input: (hp 101A Oscillator recommended)
- Frequency: 1 mc
- Amplitude: 1 vrms into 1000 ohms
- Signal-to-Noise Ratio: 60 db
- Phase and Amplitude Modulation: Less than 0.1%
- Stability: Compatible with measurement needs

Registration: 7 places, digital, in neon columns

Reads In: Microseconds, with decimal point

Start and Stop Trigger Input: Separate channels
- Input Impedance: 50 ohms
- Minimum Trigger Pulse Requirements: 3.0v peak, 0.5v/ns rise time, 5 ns width
- Trigger Polarity: Selectable, positive or negative

Reset: Manual or remote using rear terminals

Standard Frequency Counted: 100 mc

Output: 4-line BCD (1224)
- "0" state: -4v, "1" state: +19v
- Impedance: 100K, each line
- Print Command: Step from -6 to +13v, dc coupled, 2000-ohm source

Hold-Off Requirements: Any voltage from ground to +12 volts, inclusive

External Reset: -13v pulse, 30 μs minimum duration

Accessories Furnished: Two AC-16K Cables, 4 ft long, male BNC connectors

Operating Temperature Range: -20°C to +65°C

Power Requirements: 115 or 230 volts ±10%, 50 to 60 cps, 50 watts

Dimensions: 16-3/4 in. wide, 3-1/2 in. high, 11-1/2 in. deep; hardware furnished for installation in 19-in. wide by 3-1/2-in. high rack mount

Complementary Equipment:
- hp Model 101A 1 MC Oscillator
- hp Model 562A Digital Recorder

MP-S-1064
LD-M-530

Figure 1-1. Model 5275A Time Interval Counter with Specifications

Table 1.1-1. Specifications

ACCURACY:
Identical to input device used.

PRINTING RATE:
5 lines per second, maximum.

COLUMN CAPACITY:
To 11 columns (12 available on special order).

PRINT WHEELS:
12 positions, numerals 0 through 9, a minus sign, and a blank. Other symbols available.*

INPUT REQUIREMENTS:
Data Input: Parallel entry, BCD (1224, 1248 or 1242) or 10-line, see Options, "1" state must differ from "0" state by at least 4 volts but by no more than 75 volts.

Reference Voltages: BCD codes require both "0" and "1" state references. 10-line codes require reference voltage for "0" state. Reference voltages may not exceed ±150 volt to chassis. **Input impedance is approximately 270K ohms.

HOLD-OFF SIGNALS:
Both polarities are available simultaneously for BCD codes and are diode coupled; 10 ma maximum load +15 volt open circuit from 1K source, -5 volt open circuit from 2.2K source. No 160 ms hold-off is provided for 10-line codes.

PRINT COMMAND:
+ or - pulse, 6 to 40 volts amplitude, 20 μs or greater in width, ac coupled.

ANALOG OUTPUT (Optional):
(From 1224 or 1248 boards.) Accuracy is ±0.5% of full scale or better. 100 mv for potentiometer recorder; 0.5 megohm minimum load resistance. 1 ma into 5000 ohms maximum for galvanometer recorder.

TRANSFER TIME:
2 ms for BCD codes.

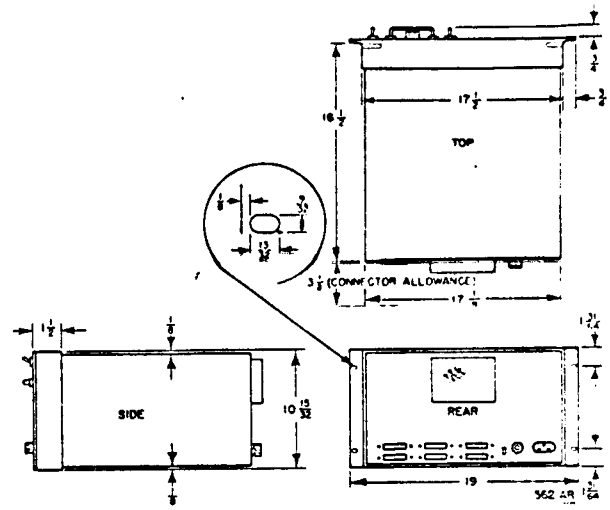
PAPER REQUIRED:
hp folded paper tape (15,000 prints per packet with single spacing), or standard 3-inch roll tape.

LINE SPACING:
Zero, single or double. In "zero" does not print, paper does not advance.

POWER REQUIREMENTS:
115 or 230 volts ±10%, 50 to 60 cps, approximately 130 watts. (4 print per sec maximum at 50 cps; 50 cps model with 5 prints per second available.)

DIMENSIONS:
Cabinet Mount: 20-3/4 inches wide
12-1/2 inches high
18-1/2 inches deep

Rack Mount:



WEIGHT:
Cabinet Mount: Net 35 lb

Rack Mount: Net 30 lb

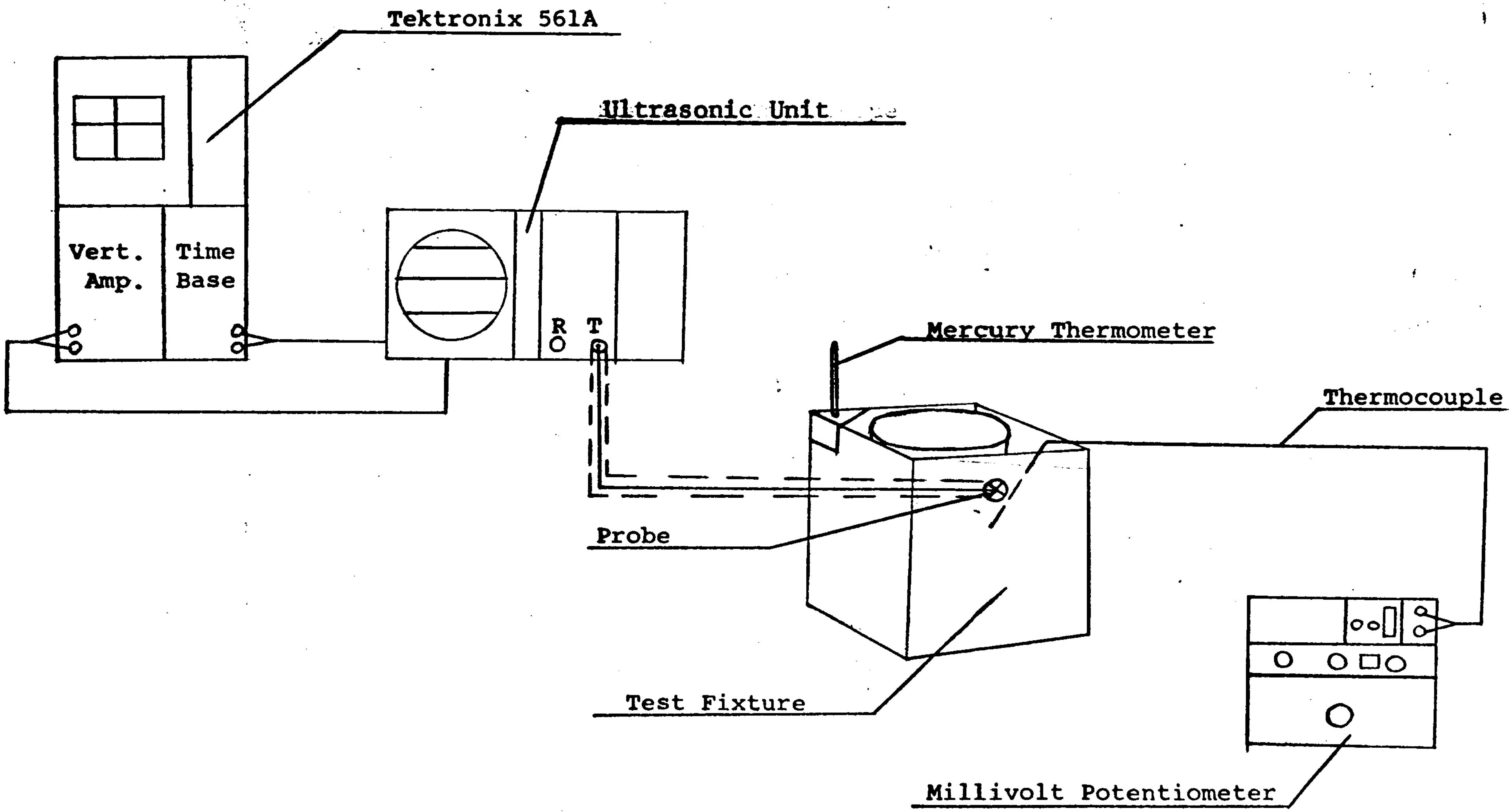
ACCESSORIES AVAILABLE:
560A-131A folded paper tape, 24-packet carton. 560A-131B paper for diazo copies, 24-packet carton. No. 9283-0002 Inked Ribbon.

ACCESSORIES FURNISHED:
One packet folded paper tape. 560A-95N Service Kit: contains machine oil, moly oil, moly grease and type cleaner.

---

*See hp Application Note 32 for information on special print wheels.

**Reference voltage requirements in the range of -9 to +16 volts may be obtained from a resistive voltage divider added to the 562A power supply module. Deriving the reference voltages from the driving source is highly recommended, however to permit full recorder flexibility and assure compatibility of input signal with respect to reference voltages.



BLOCK DIAGRAM OF ULTRASONIC TEST　　FIGURE 1

PULSE DISPLAY

FIG 2

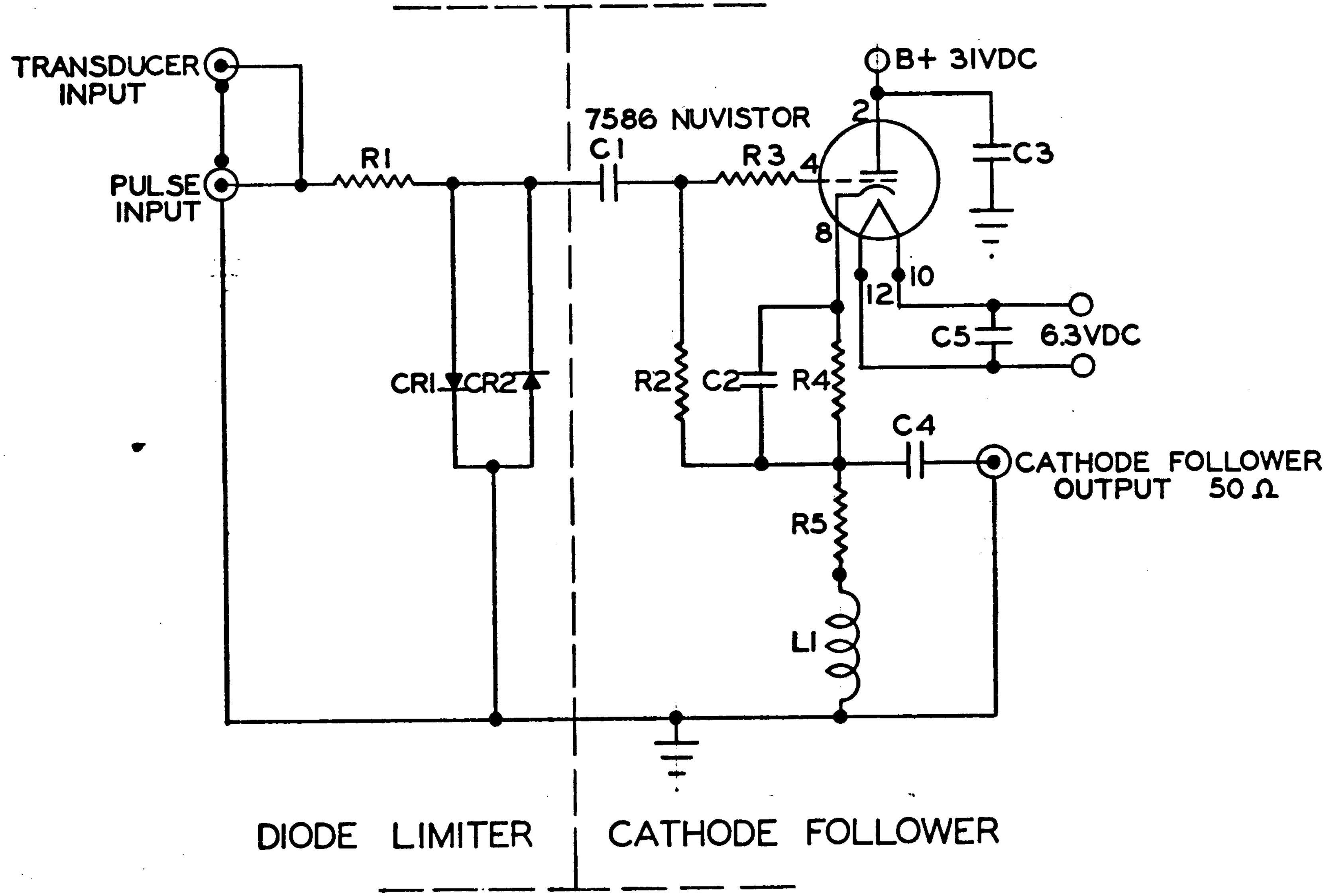
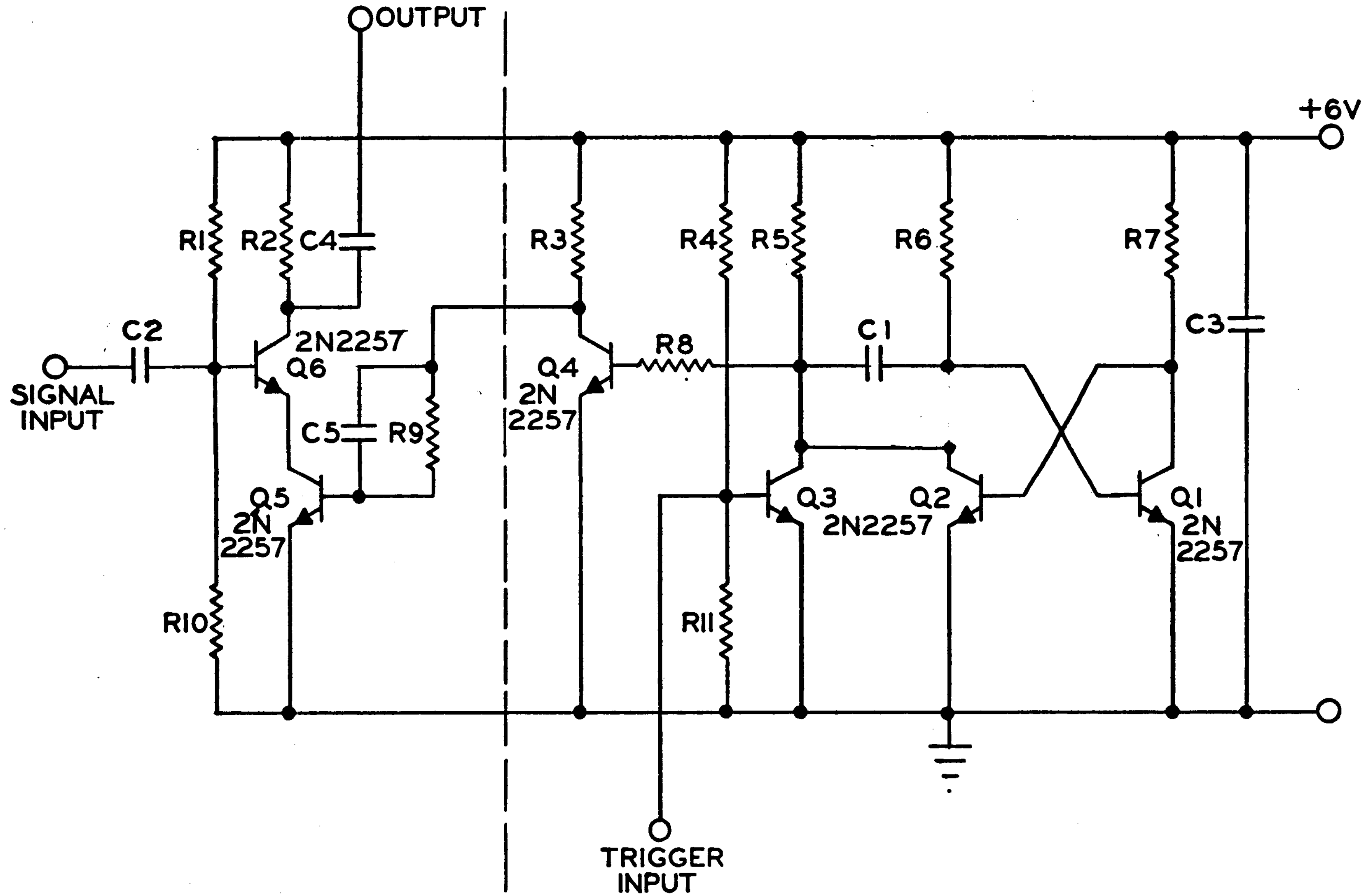

TRANSDUCER INPUT
PULSE INPUT
R1
CR1
CR2
C1
7586 NUVISTOR
R3
4
2
8
12
10
B+ 31VDC
C3
C5
6.3VDC
R2
C2
R4
C4
CATHODE FOLLOWER OUTPUT 50 Ω
R5
L1
DIODE LIMITER
CATHODE FOLLOWER

FIG. 3



NAND GATE   2 μSEC MONOSTABLE MULTIVIBRATOR

FIG. 4

0	0	0	3	5	9	3	**WATER**
0	0	0	3	5	9	3	
0	0	0	3	5	9	4	
0	0	0	0	2	0	7	**ALUMINUM**
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	3	5	9	3	**WATER**
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	0	2	0	7	**ALUMINUM**
0	0	0	0	2	0	7	
0	0	0	0	2	0	8	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	8	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	7	
0	0	0	0	2	0	8	
0	0	0	0	2	0	7	
0	0	0	3	5	9	3	**WATER**
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	4	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	4	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	4	
0	0	0	3	5	9	4	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	4	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	4	
0	0	0	3	5	9	4	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	
0	0	0	3	5	9	3	

READOUT SAMPLE

FIGURE 6